

## **AMENDMENTS TO THE CLAIMS**

Please amend the claims as follows:

### **1-24. (Cancelled)**

25. **(New)** A planar lightwave circuit having a core and a clad which are formed on a substrate, comprising:

at least one input optical waveguide which inputs signal light;

mode coupling means for coupling a fundamental mode which is part of the inputted signal light, to at least either of a higher-order mode and a radiation mode, or mode re-coupling means for re-coupling at least either of the higher-order mode and the radiation mode to the fundamental mode; and

at least one output optical waveguide which outputs signal light;

said mode coupling means or said mode re-coupling means being an optical waveguide which has at least one of a core width and height varied continuously.

26. **(New)** A planar lightwave circuit as defined in claim 25, wherein the variation of at least one of the core width and height of the optical waveguide is within  $\pm 8 \mu\text{m}$  per unit length (1  $\mu\text{m}$ ) in a propagation direction of the signal light.

27. **(New)** A planar lightwave circuit as defined in claim 25, wherein said mode coupling means or said mode re-coupling means is an optical waveguide which has at least one of the core width and height made zero partly.

28. **(New)** A planar lightwave circuit as defined in claim 26, wherein said mode coupling means or said mode re-coupling means is an optical waveguide which has at least one of the core width and height made zero partly.

29. **(New)** A planar lightwave circuit as defined in claim 25, wherein at least one of said mode coupling means and said mode re-coupling means includes at least one insular core portion which is spaced from the core of said optical waveguide.

30. **(New)** A planar lightwave circuit as defined in claim 26, wherein at least one of said mode coupling means and said mode re-coupling means includes at least one insular core portion which is spaced from the core of said optical waveguide.

31. **(New)** A planar lightwave circuit as defined in any of claims 25, wherein at least one of said mode coupling means and said mode re-coupling means includes at least one insular clad portion having a refractive index equal to that of the clad, within the core of the optical waveguide.

32. **(New)** A planar lightwave circuit as defined in any of claims 26, wherein at least one of said mode coupling means and said mode re-coupling means includes at least one insular clad portion having a refractive index equal to that of the clad, within the core of the optical waveguide.

33. **(New)** A planar lightwave circuit comprising an optical waveguide lens which has a core and a clad formed on a substrate, wherein the optical waveguide lens comprises:

at least one input optical waveguide which inputs signal light;

mode coupling means for coupling part of the inputted signal light to a higher-order mode and a radiation mode;

mode re-coupling means for re-coupling the signal light coupled to the higher-order mode and the radiation mode by said mode coupling means, to output signal light; and

at least one output optical waveguide for outputting the output signal light;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has at least one of a core width and height varied continuously.

34. **(New)** A planar lightwave circuit comprising a cross waveguide in which at least two optical waveguides having a core and a clad formed on a substrate cross, wherein the cross waveguide comprises:

at least two input optical waveguides which input signal light;

mode coupling means for coupling part of the inputted signal light to a higher-order mode and a radiation mode;

mode re-coupling means for re-coupling the signal light coupled to the higher-order mode and the radiation mode by said mode coupling means, to output signal light;

at least two output optical waveguides which output the output signal light, and

an optical-waveguide crossing portion being a part at which two virtual optical waveguides rectilinearly extending from the input waveguides toward the output waveguides overlap;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has a core width varied continuously;

said optical-waveguide crossing portion being such that a core width of an optical waveguide at a position between an end of said optical-waveguide crossing portion on a side of said input optical waveguides and a central part of said optical-waveguide crossing portion is greater than the core width of the optical waveguide at an end of said optical-waveguide crossing portion on the side of said input optical waveguides and the core width of the optical waveguide at the central part of said optical-waveguide crossing portion, and that the core width of the optical waveguide at a position between the central part of said optical-waveguide crossing portion and an end of said optical-waveguide crossing portion on a side of said output optical waveguides is greater than the core width of the optical waveguide at the central part of said optical-waveguide crossing portion and the core width of the optical waveguide at the end of said optical-waveguide crossing portion on the side of said output optical waveguides.

35. **(New)** A planar lightwave circuit comprising an optical branch circuit which has a core and a clad formed on a substrate, wherein the optical branch circuit comprises:

one input optical waveguide which inputs signal light;

mode coupling means for coupling part of the inputted signal light to a higher-order mode and a radiation mode;

mode re-coupling means for re-coupling the signal light coupled to the higher-order mode and the radiation mode by said mode coupling means, to output signal light; and

at least two output optical waveguides which output the output signal light;

said mode coupling means and said mode re-coupling means being optical waveguides each of which has a core width varied continuously.

36. **(New)** A planar lightwave circuit comprising a slab type coupler which has a core and a clad formed on a substrate, wherein the slab type coupler comprises:

at least one, first input/output optical waveguide which inputs/outputs a light signal;

an optical slab waveguide which is optically connected to the first input optical waveguide; and

at least two, second input/output optical waveguides which are optically connected to said optical slab waveguide, and which input/output light signals; and

that said second input/output optical waveguides comprise mode coupling means for coupling part of the inputted/outputted signal light to at least either of a higher-order mode and a radiation mode, and converting the coupled part into a plane wave at an end of said optical slab waveguide;

said mode coupling means being an optical waveguide which has a core width varied continuously.

37. **(New)** A planar lightwave circuit comprising an arrayed waveguide grating filter which has a core and a clad formed on a substrate, wherein the arrayed waveguide grating filter comprises:

- at least one input optical waveguide which inputs signal light;
- a first optical slab waveguide which is optically connected with said input optical waveguide;
- arrayed optical waveguides which are optically connected with said first optical slab waveguide, and which become longer with a predetermined waveguide length difference in succession;
- a second optical slab waveguide which is optically connected to said arrayed optical waveguides; and
- at least one output optical waveguide which is optically connected to said second optical slab waveguide; and
- that each of said arrayed optical waveguides comprises:
  - mode re-coupling means for re-coupling a higher-order mode and a radiation mode to the signal light, at a part optically touching said first optical slab waveguide; and
  - mode coupling means for coupling the signal light to the higher-order mode and the radiation mode, at a part optically touching said second optical slab waveguide;
- said mode coupling means and said mode re-coupling means being optical waveguides each of which has a core width varied continuously.

38. **(New)** A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, the method comprising:

    a refractive-index-distribution initialization step of storing initial values of a refractive index distribution of a propagation medium in the wave propagation circuit, in storage means of the computer;

    a step of setting any position of the transmission medium in a wave propagation direction thereof, as an optimized position;

    an optimized-position input/output-field computation step of computing a field in a case where the input field has propagated forwards from an inlet of the wave propagation circuit to the optimized position, and a field in a case where the desired output field has propagated backwards from an output of the wave propagation circuit to the optimized position, and then storing the fields in the storage means of the computer; and

    a refractive-index-distribution alteration step of adjusting the refractive index distribution at the optimized position so that wavefronts of the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards may agree;

    the optimized-position setting step, said optimized-position input/output-field computation step and said refractive-index-distribution alteration step being iterated while the optimized position is being changed in the wave propagation circuit.

39. **(New)** A method as defined in claim 38, wherein the input field and/or the desired output field includes a plurality of wavelengths.

40. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 39.

41. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 39.

42. **(New)** A method as defined in claim 38, wherein said refractive-index-distribution alteration step is a step of giving refractive indices each of which is proportional to a phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards, in at least some of the optimized positions.

43. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 42.

44. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 42.

45. **(New)** A method as defined in claim 38, wherein said refractive-index-distribution alteration step is a step of distributing a core in a place where the phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards is greater than a real number  $T$  greater than zero, and distributing a clad layer in a place where the phase difference is smaller than the real number  $T$ , in at least some of the optimized positions.

46. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 45.

47. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 45.

48. **(New)** A method as defined in claim 38, wherein said refractive-index-distribution alteration step is a step of distributing a core and a clad under a limitation that a size of the core becomes on the order of a wavelength of a wave, in at least some of the optimized positions.

49. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 48.

50. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 48.

51. **(New)** A method as defined in claim 38, wherein said refractive-index-distribution alteration step is a step of distributing a core and a clad layer under a limitation that the core is distributed or removed at only a boundary part between the core and the clad layer.

52. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 51.

53. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 51.

54. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 38.

55. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 38.

56. **(New)** A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, the method comprising:

a refractive-index-distribution initialization step of storing initial values of a refractive index distribution of a propagation medium in the wave propagation circuit, in storage means of the computer;

a step of setting an outlet of the wave propagation circuit as an optimized position;

a forward-propagation input-field-distribution computation step of computing a field distribution in a case where the input field has propagated forwards from an inlet of the wave propagation circuit to the output thereof, and storing the field distribution in the storage means of the computer;

a backward-propagation optimized-position output-field computation step of computing a field in a case where the output field has propagated backwards from the outlet of the wave propagation circuit to the optimized position, and storing the field in the storage means of the computer; and

a refractive-index-distribution alteration step of adjusting the refractive index distribution at the optimized position so that wavefronts of the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards may agree;

said backward-propagation optimized-position output-field computation step and said refractive-index-distribution alteration step being iterated while the optimized position is being successively changed from the outlet to the inlet along a wave propagation direction.

57. **(New)** A method as defined in claim 56, wherein the input field and/or the desired output field includes a plurality of wavelengths.

58. **(New)** A method as defined in claim 56, wherein said refractive-index-distribution alteration step is a step of giving refractive indices each of which is proportional to a phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards, in at least some of the optimized positions.

59. **(New)** A method as defined in claim 56, wherein said refractive-index-distribution alteration step is a step of distributing a core in a place where the phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards is greater than a real number  $T$  greater than zero, and distributing a clad layer in a place where the phase difference is smaller than the real number  $T$ , in at least some of the optimized positions.

60. **(New)** A method as defined in claim 56, wherein said refractive-index-distribution alteration step is a step of distributing a core and a clad under a limitation that a size of the core becomes on the order of a wavelength of a wave, in at least some of the optimized positions.

61. **(New)** A method as defined in claim 56, wherein said refractive-index-distribution alteration step is a step of distributing a core and a clad layer under a limitation that the core is distributed or removed at only a boundary part between the core and the clad layer.

62. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 56.

63. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 56.

64. **(New)** A method wherein a wave propagation circuit for obtaining a desired output field from an input field is designed by employing a computer, the method comprising:

    a refractive-index-distribution initialization step of storing initial values of a refractive index distribution of a propagation medium in the wave propagation circuit, in storage means of the computer;

    a step of setting an inlet of the wave propagation circuit as an optimized position;

    a backward-propagation output-field-distribution computation step of computing a field distribution in a case where the output field has propagated backwards from an outlet of the wave propagation circuit to the input thereof, and storing the field distribution in the storage means of the computer;

    a forward-propagation optimized-position input-field computation step of computing a field in a case where the input field has propagated forwards from the inlet of the wave propagation circuit to the optimized position, and storing the field in the storage means of the computer; and

    a refractive-index-distribution alteration step of adjusting the refractive index distribution at the optimized position so that wavefronts of the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards may agree;

    said forward-propagation optimized-position input-field computation step and said refractive-index-distribution alteration step being iterated while the optimized position is being successively changed from the inlet to the outlet along a wave propagation direction.

65. **(New)** A method as defined in claim 64, wherein the input field and/or the desired output field includes a plurality of wavelengths.

66. **(New)** A method as defined in claim 64, wherein said refractive-index-distribution alteration step is a step of giving refractive indices each of which is proportional to a phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards, in at least some of the optimized positions.

67. **(New)** A method as defined in claim 64, wherein said refractive-index-distribution alteration step is a step of distributing a core in a place where the phase difference between the field in the case where the input field has propagated forwards and the field in the case where the desired output field has propagated backwards is greater than a real number  $T$  greater than zero, and distributing a clad layer in a place where the phase difference is smaller than the real number  $T$ , in at least some of the optimized positions.

68. **(New)** A method as defined in claim 64, wherein said refractive-index-distribution alteration step is a step of distributing a core and a clad under a limitation that a size of the core becomes on the order of a wavelength of a wave, in at least some of the optimized positions.

69. **(New)** A method as defined in claim 64, wherein said refractive-index-distribution alteration step is a step of distributing a core and a clad layer under a limitation that the core is distributed or removed at only a boundary part between the core and the clad layer.

70. **(New)** A computer program characterized by allowing a computer to perform the method as defined in claim 64.

71. **(New)** A computer-readable storage medium characterized by storing therein a computer program for allowing a computer to perform the method as defined in claim 64.